Fluctuation patterns of different developmental stages of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on chickpea (*Cicer arietinum*) and their relationship with the environment

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The relative frequency of occurrence of different developmental stages of gram pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), and the dependence of its developmental stages on environmental factors, are crucial in the population management. The densities of eggs and larvae were low from December to mid-February due to prevailing cold. Owing to optimum environmental conditions, increasing densities were observed throughout March and they droppped again during the first week of April. The densities of eggs and different larval instars of *H. armigera* were significantly positively correlated with temperature, and significantly negatively correlated with the average morning relative humidity (RH;%) but not with the average evening RH (%).

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1. Introduction

The gram pod borer *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) plays a detrimental role in the destruction of the crop of chickpea (*Cicer arietinum*) that is the World's third most important pulse crop (Rheenen & Van Rheenen 1991), grown in the semi-arid tropics around the world (Jodha & Rao 1987). The countries affected by the devastating attack of *H. armigera* on chickpea include India, Pakistan, Turkey, Mexico, Iran, Australia and Ethiopia (FAO 1994). *H. armigera* often causes substantial damage to the crop at the pod formation compared to other stages (Lal *et al*. 1985, Naresh & Malik 1986, Deka *et al*. 1987).

The moths begin ovipositing on chickpea in the seedling stage but this oviposition behaviour is influenced by adverse climatic and geographical conditions (Tahhan *et al*. 1982, Lal 1996). *H. armigera* start devouring the young shoots, leaves or pods available soon after hatching. Studies on the population fluctuations of *H. armigera* on ckickpea have demonstrated the occurrence of population peaks in different months of the year in respective locations (Dakwale &

Singh 1980, Deka *et al*. 1989, Prasad *et al*. 1989, Patnaik & Senapati 1996, Khurana 1997, Patel & Koshiya 1997, Patel & Koshiya 1999). The population peaks generally correspond to the full bloom and pod formation stage of the crop (Deka *et al*. 1987, Lal 1996, Patel & Koshiya 1999). Many other factors, such as temperature, humidity (Yadava & Lal 1988, Yadava *et al*. 1991), rainfall (Tripathi & Sharma 1985), predators (Thakur *et al*. 1995, Gunathilagaraj 1996) and parasitoids (Bhatnagar 1980, Srinivas & Jayaraj 1989, Thakur *et al*. 1995) are known to affect population densities of *H. armigera* on chickpea.

The extent of damage caused by *H. armigera* to chickpea depends on the number of larval pests per plant and on its developmental stages (Tripathi & Sharma 1984). An account of the population, with reference to eggs and larval instar densities under field conditions, gives a good indication on plausible outbreak of damaging stage. In this paper, we report population densities of *H. armigera* in terms of eggs and larval instars vis-à-vis environmental factors.

2. Material and methods

The study was carried out at the experimental fields of Ayub Agricultural Research Institute, Faisalabad, Pakistan, during Winter & Spring 2001–02. Chickpea variety cv-90395 was sown during mid November, with distance between rows 45 cm, in four plots of 100.8 m^2 each. The plots were parts of the same field with similar environmental conditions and soil quality. The moths oviposited throughout the cropping season and there were many overlapping cohorts. Observations were recorded in weekly intervals throughout the growing season by counting the number of eggs and different larval instars of *H. armigera* on randomly-selected twenty plants while walking diagonally across the field. The identification of different larval instars was based on colour pattern and size, with modifications of Mathews & Tunstall (1994):

- 1st instar, whitish yellow,
- 2nd instar, yellow,
- 3rd instar, greenish yellow with trivial white streaks,
- 4th instar, yellowish green with dominant white streaks on the body,
- 5th instar, green with dominant white streaks,
- 6th instar, green with only dominant lateral streaks.

The association of maximum and minimum temperatures and average morning and evening relative humidity (RH;%) with the fluctuations of the different developmental stages of *H. armigera* were tested using parametric correlation.

3. Results

3.1. Population fluctuations

The first appearance of *H. armigera* was in the 49th standard week on chickpea crop, and the overall population kept on increasing until it reached 8 larvae per 20 plants during 1st standard week. After that, the population started declining (2 eggs/larvae per 20 plants) during the 5th and 6th standard weeks. The population of *H. armigera* then started to rise again, and its second peak (109 eggs/larvae per 20 plants) was observed in the 13th standard week before declining again in the following week (93 eggs/larvae per 20 plants) (Fig. 1).

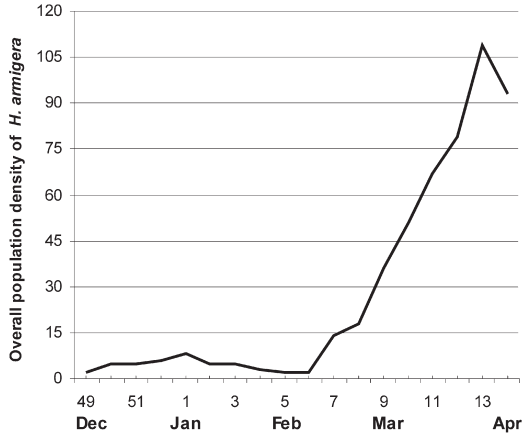

Fig. 1. Overall population density of gram pod borer (*H. armigera*) on chickpea during Winter & Spring 2001–2002.

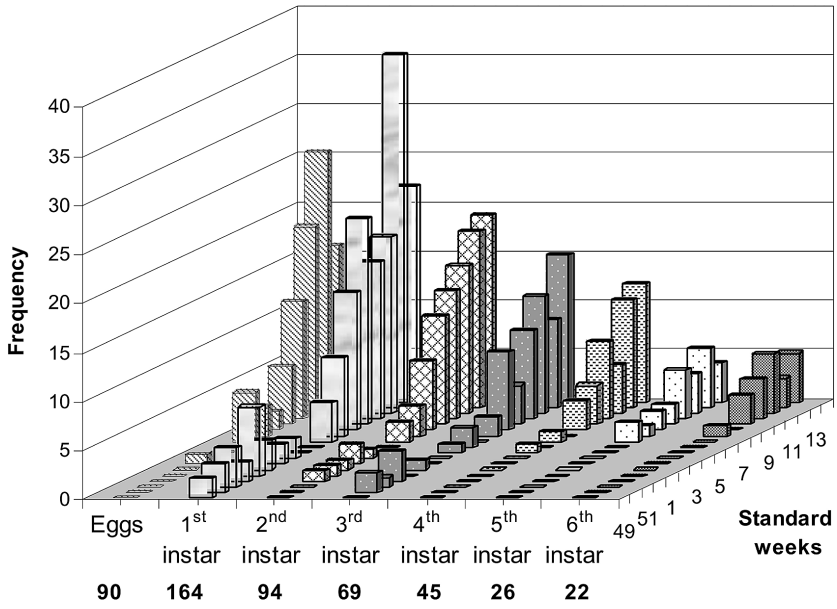

Fig. 2. Fluctuations in the occurrence of eggs and larval instars of *H. armigera* on chickpea during Winter & Spring 2001– 2002. The numbers below the developmental stages show total numbers.

The eggs of *H. armigera* were first noticed in the 3rd standard week (Fig. 2). However, consistent appearance of the eggs was observed from 7th standard week onward. During this period, a minimum number of eggs (2 eggs per 20 plants) was observed during the 9th standard week, while the maximum was (26 eggs per 20 plants) on 13th standard week. The fluctuations in the population density of *H. armigera* in terms of 1st instar larvae showed a very similar pattern to that of its overall population (Fig. 1), except that none of the 1st instar larvae were confronted during 5th and 6th standard weeks. Contrary to the 1st instar larvae, none of the 2nd instar larvae was observed during the 49th, 50th and 51st, 5th and 6th standard weeks. Very low density of 2nd instar larvae was noticed during 52nd and 1st to 4th standard weeks. However, consistent appearance of the 2nd instar larvae was observed from 7th standard week onward. The maximum number of 2nd instar larvae, i.e. 19 larvae per 20 plants, was observed during the 14th standard week. The population density of the 3rd instar larvae showed much more fluctuations than that of any other larval instar. Steady appearance of 3rd instar larvae was noticed from 8th standard week onward; a maximum of 15 larvae per 20 plants was observed during the 14th standard week. The 4th instar larvae were not recorded from 49th to 4th standard weeks. However, during 9th standard week onward they were found, with a maximum density of 12 larvae per 20 plants. The 5th instar larvae did not occur from 49th to 6th standard week; the 7th standard week onward they were present. The lowest population density (1 larva per 20 plants) of 5th instar larvae was observed during the 8th standard week, and the highest (6 larvae per 20 plants) during 13th standard week. The 6th instar larvae first appeared during the 8th standard week. Their consistent appearance was noticed from 10th standard week onward.

Total counts of larvae in decreasing order from the 1st to the 6th instar were 164, 94, 69, 45, 26, 22, respectively, while the total counts of eggs was comparable to that of 2nd instar (Fig. 2).

3.2. Correlations

There was a significant positive correlation among the number of eggs and larval instars of *H. armigera* and the average maximum and minimum temperatures (Fig. 3a–b), and significant negative correlations existed between the number of eggs and larval instars of *H.*

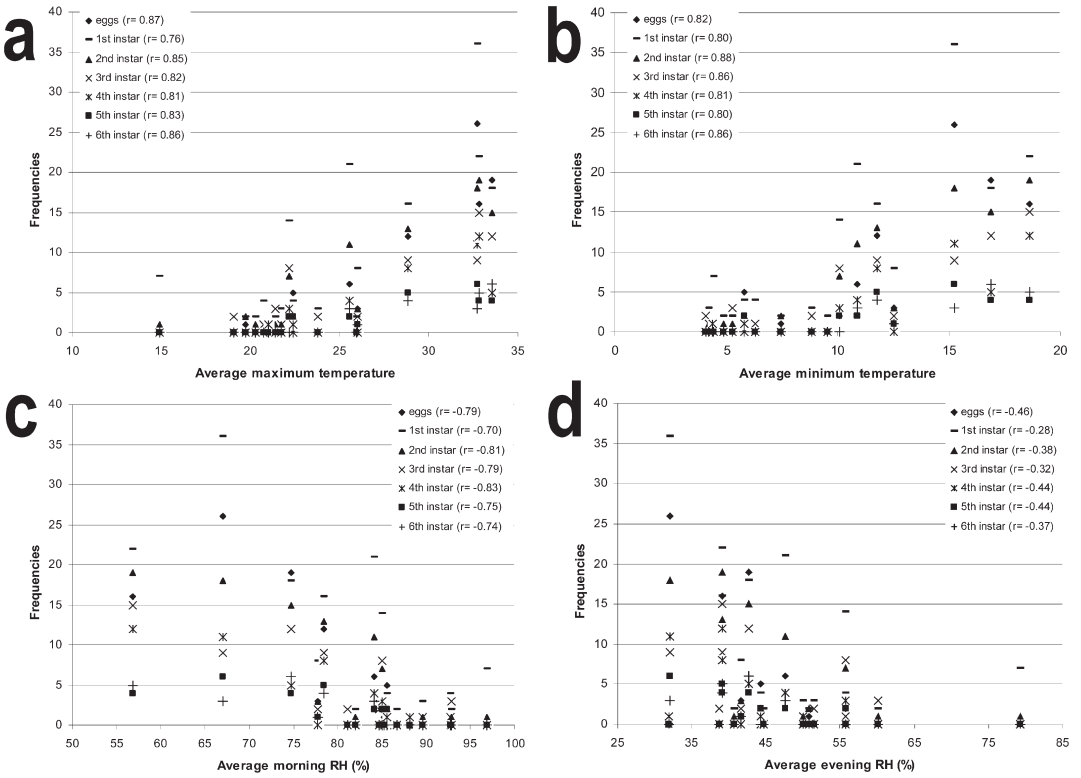

Fig. 3. Frequencies of developmental stages of *H. armigera* on chickpea. All the correlation coefficients shown in parentheses are significant (p <0.001). – a. Frequency vs. average maximum temperature. – b. Frequency vs. minimum temperature. – c. Frequency vs. average morning RH (%). – d. Frequency vs. average evening RH (%).

armigera and the average morning RH (%) (Fig. 3c). They did not correlate with average evening percent relative humidity (%) (Fig. 3d).

4. Discussion

The chickpea variety cv-90395 appeared to be vulnerable to the attack of *H. armigera* larvae, compared to an earlier report by Deka *et al.* (1987). Apart from the inherent susceptibility, the suitability of this variety for late sowing may facilitate the attack of *H. armigera* (Chaudary & Sachan 1995, Prasad & Sing 1997, Borah 1998). In addition, variation in the environmental factors and specific geographical location could also facilitate the pest (Tahhan *et al*. 1982, Lal 1996). Timely irrigation of the field also increases the larval density of *H. armigera*, compared to non-irrigated fields (Qadeer & Singh 1989).

After its first appearance, the pest started to build up slowly, but when the temperature fell in January and February, the pest population declined (Yadava & Lal 1988, Lal 1996). The minimum number of the early-instar larvae of *H. armigera* during winter months was due to the fact that the early instar larvae have less tolerance to the prevailing cold (Olla & Saini 2000). Complete absence of late instar larvae in December and January in the present study could be due to exceptionally low temperatures. The population of *H. armigera* flourished during the second half of February, and outbreaks were found throughout March (Lal 1996), probably owing to the optimum temperature and abundant food in the form of pods. This is in accordance with other studies (Dakwale & Singh 1980, Deka *et al.* 1987, Lal 1996, Patel & Koshiya 1999). Contrary to this,

Saini and Juglan (1998) observed only a few larvae present at the pod formation stage.

The correlation of the larval population density of *H. armigera* with mean temperature, and with relative humidity ranges observed in the present study, was in agreement to other studies (e.g. Mehto *et al*. 1985, Yadava *et al*. 1991). The mean temperature exhibited a significant positive correlation with population density, while mean relative humidity ranges had a significant negative correlation. However, Patnaik & Senapati (1996) found a negative correlation between mean temperature ranges and larval incidence.

The aim of the present work was to monitor the population densities of eggs and larval instars, and identify the interrelationship with environment for sustainable control to minimize chickpea losses. Finding the peaks of eggs and different larval instars can be utilized for effective Integrated Pest Management using parasitoids, predators and insecticides. By combining results of experimental studies and those reported here, it should be possible to predict the pest populations and improve control strategies.

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